

WHAT IS CLAIMED IS:

1. A non-aqueous electrolytic solution comprising an organic solvent and a lithium salt, which further contains a pyridine compound represented by the following formula (1) :



wherein R¹ to R⁵ each independently represents a hydrogen atom or a substituent composed of an alkyl group having 1 to 20 carbon atoms, an alkenyl group having 2 to 20 carbon atoms, an alkoxy group having 1 to 4 carbon atoms, an aryloxy group having 6 to 10 carbon atoms, a dialkylamino group having 2 to 8 carbon atoms, a 3-thienyl group, a cyano group, a fluoro group, an alkoxy carbonyl group having 1 to 6 carbon atoms, an aryl carbonyl group having 6 to 10 carbon atoms, an alkyl carbonyl group having 1 to 12 carbon atoms, a cyano alkyl group having 1 to 4 carbon atoms, an alkoxy carbonyl alkyl group having 3 to 13 carbon atoms, a pyrrol-1-ylmethyl group, a 1-pyrrolidinyl group, a 1-piperidino group, a phenyl group, a 1H-pyrrol-1-yl group, an alkoxy alkyl group having 2 to 12 carbon atoms, a dialkylamino alkyl group having 3 to 18 carbon atoms, an aryloxy group having 6 to 10 carbon atoms, an aryl alkyl group the aryl moiety of which has 6 to 10 carbon atoms

100-100-100-100-100

and the alkyl moiety of which has 2 to 6 carbon atoms, an isothiocyanato group, a dialkylaminocarbonyl group having 2 to 8 carbon atoms, a 5-oxazole group, a trifluoromethyl group, a 1-pyrrolidine-2,5-dione group, a 1H-pyrrol-1-ylalkyl group having 1 to 6 carbon atoms, a 4,5-dihydro-oxazol-2-yl group, a 1,3,4-oxadiazol-2-yl group, a nitro group, a 1-piperidinyl group, a 1-alkylpyrrol-2-yl group having 1 to 6 carbon atoms, a 4-1,2,3-thiadiazole group, a 2-1,3,4-oxadiazole group, a morpholino group and a 1-pyrrolin-2-yl group, with the proviso that, at least one of R¹ to R⁵ represents aforesaid substituent and that, when R¹ to R⁵ are a hydrogen atom or an alkyl group, at least one of R¹ to R⁵ is an alkyl group having 2 or more carbon atoms and sum of the carbon atoms of R¹ to R⁵ is 3 or more and that, when R¹ to R⁵ each independently represents a phenyl group, two or more of R¹ to R⁵ represent phenyl groups.

2. The non-aqueous electrolytic solution as claimed in claim 1, wherein R¹ to R⁵ in the formula (1) each independently represents a hydrogen atom or a substituent composed of an alkyl group having 1 to 20 carbon atoms, an alkenyl group having 3 to 20 carbon atoms, an alkoxy group having 1 to 4 carbon atoms, an aryloxy group having 6 to 10 carbon atoms and a dialkylamino group having 2 to 8 carbon atoms.

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3. The non-aqueous electrolytic solution as claimed in claim 1, wherein at least one of R¹ to R⁵ in the formula (1) represents an alkyl group having 1 to 20 carbon atoms with the proviso that, when R¹ to R⁵ are a hydrogen atom or an alkyl group, at least one of R¹ to R⁵ is an alkyl group having 2 or more carbon atoms and sum of the carbon atoms of R¹ to R⁵ is 3 or more.
4. The non-aqueous electrolytic solution as claimed in claim 1, wherein, when R¹ to R⁵ in the formula (1) are a hydrogen atom or an alkyl group, at least one of R¹ to R⁵ is an alkyl group having 3 or more carbon atoms.
5. The non-aqueous electrolytic solution as claimed in claim 1, wherein, when R¹ to R⁵ in the formula (1) are a hydrogen atom or an alkyl group, sum of the carbon atoms of R¹ to R⁵ is 4 or more.
6. The non-aqueous electrolytic solution as claimed in claim 1, wherein, when R¹ to R⁵ in the formula (1) are a hydrogen atom or an alkyl group, sum of the carbon atoms of R¹ to R⁵ is 60 or less.
7. The non-aqueous electrolytic solution as claimed in claim 1, wherein R¹ and R⁵ in the formula (1) are the aforesaid substituents.
8. The non-aqueous electrolytic solution as claimed in claim 7, wherein R³ is also the aforesaid substituent.
9. The non-aqueous electrolytic solution as claimed in

claim 1, wherein said pyridine compound is at least one member selected from the group consisting of 2-propylpyridine, 3-propylpyridine, 4-propylpyridine, 2-isopropylpyridine, 4-isopropylpyridine, 3-butylpyridine, 4-butylpyridine, 4-isobutylpyridine, 2-methyl-5-butylpyridine, 2-tert-butylpyridine, 4-tert-butylpyridine, 2,6-di-tert-butylpyridine, 2,6-di-tert-butyl-4-methylpyridine, 2,4,6-tri-tert-butylpyridine, 2-tert-butyl-6-methylpyridine, 2-tert-butyl-4-methylpyridine, 4-tert-butyl-2-methylpyridine, 2-tert-butyl-6-isopropylpyridine, 4-(5-nonyl)pyridine, 2-pentylpyridine, 2-(3-pentyl)pyridine, 4-(3-pentyl)pyridine, 2-hexylpyridine, 4-octylpyridine, 2-undecylpyridine, 2-(1-butylpentyl)pyridine, 4-(1-propenylbutenyl)pyridine, 4-(1-butenylpentenyl)pyridine, 2,6-di-tert-butyl-4-(dimethylamino)pyridine, 2-(3-thienyl)-pyridine, 2-cyanopyridine, 2-fluoropyridine, pentafluoropyridine, 2-dimethylaminopyridine, 2-methoxypyridine, 2-pyridinecarboxylic acid ethyl ester, 2-benzoylpyridine, 2-acetylpyridine, 2-(cyanomethyl)pyridine, 4-(3-phenylpropyl)pyridine, 2-pyridylacetic acid methyl ester, 3-(pyrrol-1-ylmethyl)pyridine, 4-(1-pyrrolidinyl)pyridine, 4-piperidinopyridine, 2,4,6-triphenylpyridine, 2-(1H-pyrrol-1-yl)pyridine, 2-methoxyethylpyridine, 4-(2-diethylaminoethyl)pyridine, 2-phenoxyypyridine, 3-pyridylisothiocyanate, N,N-dimethylnicotinamide, 5-(pyrid-4-

yl)oxazole, 3-trifluoromethylpyridine, 1-(3-pyridyl)-
pyrrolidine-2,5-dione, 4-(1H-pyrrol-1-ylmethyl)pyridine,
3-(4,5-dihydrooxazol-2-yl)pyridine, 4-(1,3,4)oxadiazol-2-
ylpyridine, 3-nitropyridine, 2,6-di(1-piperidinyl)pyridine,
3-(1-methylpyrrol-2-yl)pyridine, 3-methoxypyridine, 4-(4-
pyridyl)-1,2,3-thiadiazole, 2-(3-pyridyl)-1,3,4-oxadiazole,
2,6-dimorpholinopyridine and 2-(1-pyrrolin-2-yl)pyridine.

10. The non-aqueous electrolytic solution as claimed in
claim 1, wherein said pyridine compound is a pyridine
compound having a bonding energy of 16 kcal/mol or more
with hydrofluoric acid determined according to the
following calculation method:

(method for calculating bonding energy)

A bonding energy between the pyridine compound and
hydrofluoric acid is calculated according to ab initio
method (program: Gaussian 94; base set: 3-21G); and the
term "bonding energy" as used herein means a value
obtained by summing the energy values of the pyridine
compound and hydrofluoric acid determined by geometry
optimization of each of them, and subtracting from the sum
the energy value determined by geometry optimization of an
adduct of the pyridine compound and hydrofluoric acid
connecting to each other through nitrogen atom of the
pyridine compound and hydrogen atom of hydrofluoric acid,
that is,

(Bonding energy) = (Energy value of the pyridine compound)
+ (Energy value of hydrofluoric acid) - (Energy value of
the adduct between the pyridine compound and hydrofluoric
acid).

11. The non-aqueous electrolytic solution as claimed in claim 1, wherein said pyridine compound is contained in an amount of 0.001% by weight based on the sum of the organic solvent and the lithium salt to saturation.

12. The non-aqueous electrolytic solution as claimed in claim 1, wherein said lithium salt is a compound containing a fluorine atom or fluorine atoms.

13. A secondary battery, which comprises the non-aqueous electrolytic solution claimed in claim 1, a positive electrode and a negative electrode.

14. The secondary battery as claimed in claim 13, wherein said positive electrode comprises an active material for a positive electrode, said active material for a positive electrode being a lithium transition metal oxide.

15. The secondary battery as claimed in claim 14, wherein said lithium transition metal oxide is lithium manganese oxide or lithium cobalt oxide.

16. The secondary battery as claimed in claim 15, wherein said lithium manganese oxide is spinel type lithium manganese oxide.

17. The secondary battery as claimed in claim 15, wherein

said lithium manganese oxide is lithium manganese oxide wherein part of manganese sites are occupied by other element.

18. The secondary battery as claimed in claim 17, wherein said other element occupying the manganese sites is at least one metal element selected from the group consisting of Al, Ti, V, Cr, Fe, Co, Li, Ni, Cu, Zn, Mg, Ga and Zr.

19. The secondary battery as claimed in claim 13, wherein said negative electrode comprises an active material for a negative electrode, said active material for a negative electrode being a carbonaceous substance.

20. The secondary battery as claimed in claim 19, wherein said carbonaceous substance is graphite having a d value of lattice plane (002 plane) in X ray diffraction of 0.335 to 0.340 nm.